

RIVERS AND FLOODS

[River and Flood Division, W. J. MOXOM temporarily in charge]

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The outstanding feature of the floods that occurred during the months of January and February 1937 was the unprecedented flood in the Ohio and lower Mississippi Valleys. Floods of lesser severity occurred elsewhere over the country; and in the following discussion of the important features, causes, etc., of all the floods that occurred during January and February, the floods have been arranged according to drainage areas. Reports by the officials of the various district centers in the Ohio and lower Mississippi Valleys have been added to the discussion of the Ohio-Mississippi flood.

ST. LAWRENCE DRAINAGE

Minor flooding occurred in the Maumee Valley in Indiana and Ohio near the middle of January. No damage of consequence was incurred.

ATLANTIC SLOPE DRAINAGE

Precipitation was above normal over most of the Atlantic Slope Drainage during January, ranging from normal to as much as twice normal or more over portions of the Middle Atlantic States. The precipitation was quite evenly distributed over the whole month so that, although flooding occurred in the upper Susquehanna River and tributaries in New York and in all the rivers from the Potomac River southward to Florida, no serious flooding resulted.

Additional heavy rains during February, which occurred on the 8th and 9th and again on the 20th and 21st, again brought most of these rivers slightly above flood stage.

No losses of consequence were reported in the river basins with the exception of the following: Roanoke River, about \$73,000; Neuse River, \$14,000; and the Pee Dee River, \$13,000, all mostly due to suspension of business; Santee River, \$25,000, mostly to crops and suspension of logging industry; and Altamaha River, about \$25,000.

EAST GULF OF MEXICO DRAINAGE

The rainfall was above normal over the northern portion of the drainage area during January and in portions of Mississippi it was more than three times normal. During February the southeastern portion of the drainage area received normal to slightly above normal precipitation.

The lower portion of the Apalachicola River reached flood stage on January 4 and continued above flood stage at the close of February, with only a slight interruption on February 20. The flooding was not serious, however, and no damage of consequence was reported.

Minor flooding occurred in the Alabama River and its tributaries during January, and only slight damage was caused by flooding of the lowlands.

Heavy rains on January 1 and 2 over the entire watersheds of both the Black Warrior and Tombigbee Rivers were followed by rapid rises throughout the entire system and the Black Warrior at Tuscaloosa, Ala., reached a crest nearly 13 feet above flood stage on January 3. Heavy rains occurred again at frequent intervals during the month of January and the Tombigbee River continued to rise steadily until the first part of February, when a

crest stage of nearly 25 feet above flood stage was reached at Lock No. 3.

The flooding in the Tombigbee River continued through most of February and at some points the stages were still above flood stage at the close of February. As there were no crops planted, the damage was small, the larger part being the loss of wages due to suspension of lumbering operations. The total losses reported were about \$16,000.

Unusually heavy rain occurred over much of the Pascagoula and Pearl River watersheds during January. The heaviest rainfall reported for the month was at Hickory, Miss., where 21.48 inches was recorded. At Meridian, Miss., slightly less, 18.77 inches, was recorded.

The rainfall, however, was very well distributed throughout the month, thus resulting in relatively moderate floods and the damage was not great. The total loss reported for the Pascagoula and Pearl River systems was slightly less than \$50,000.

UPPER MISSISSIPPI DRAINAGE

Minor floods occurred during January in the Illinois, Meramec, and Bourbeuse Rivers. They were due mostly to thawing and ice movements. No damage of consequence was reported.

Moderate to heavy rains began over southeastern Iowa, northern Illinois, and southern Wisconsin on February 19, becoming heaviest on the 20th and 21st, and continuing into the 22d. The snow cover varied from moderately heavy to light in this region. The heavy rains and moderate temperatures melted the ice and snow and the runoff was rapid. The streams began swelling, breaking up the ice and forming gorges. Rather severe flooding resulted, principally from the forming and breaking of ice gorges, in most of the rivers in this area. As the flooding continued into March in some places a more complete report on these floods will be given in the March number of the REVIEW.

The stages in the upper Mississippi River remained quite low during the month of January and the first part of February, but a rise began the latter part of February. Stages did not exceed flood stage, however, except at Keithsburg, Ill., where a stage 0.3 foot above flood stage was reached on February 25.

MISSOURI DRAINAGE

The only flooding during January occurred on the 31st, when the Grand River was in flood at Chillicothe, Mo. No damage occurred.

A more general flood occurred in February in the Grand River. The flood was light except at Chillicothe, Mo., where two crests occurred, on February 12-13 and again on February 18-19, with stages 8 or 9 feet above flood stage. No great amount of damage occurred, due largely to the time of the year.

The outstanding fact about the floods of January and February in the Grand River was their frequency when due almost entirely to melting of sleet, snow, and ice.

The lowest stage of record on the Missouri River at Kansas City, Mo., occurred on January 9 and 10. The gage reading was 2.7 feet below zero.

OHIO DRAINAGE

The great flood of January–February 1937 in the Ohio Valley actually had its beginning in the latter part of December 1936, when moderate to heavy rains began over the entire Ohio River watershed. After several months of comparatively low stages in the Ohio River a general rise began in the lower portion during the last week of December 1936 and developed within 1 month's time into the greatest flood of record.

The flood resulted from excessive rains which followed during the month of January. There was practically no snow on the ground at the beginning of the month and whatever amounts fell subsequently were absorbed in the general rains or floods, and had no appreciable effect on the flood.

Figure 1 shows that the area of excessive precipitation coincided almost exactly with the drainage basins of the Ohio River and the upper portion of the lower Mississippi River; the greatest concentration occurring in the lower portions of the Ohio Valley. The total precipitation for January in this latter area was more than four times the amount of precipitation which normally occurs during the month.

The cause of the abnormal weather during January 1937 has been described by C. L. Mitchell, Forecaster, Washington Forecast District, as follows:

During almost the entire month of January, an abnormal barometric pressure distribution prevailed over most of the northern hemisphere. Inasmuch as the movements of air masses, as shown by the wind directions and speeds, are determined by pressure gradients, the weather conditions resulting from the movements and interactions of the air masses, have likewise been abnormal over large areas. These unusual weather conditions, insofar as they affected the United States, can be summarized briefly as follows:

Pressure was persistently and abnormally high at, and up to at least 3 miles above, the surface of the earth from the south Atlantic States and the eastern Gulf of Mexico eastward over the Bahamas and the region of Bermuda, as well as over the Pacific Ocean west of our coast and northeast of the Hawaiian Islands. This pressure

distribution resulted in a continuous northward and northeastward movement of tropical air masses over the area roughly from Louisiana and Tennessee eastward to the Atlantic States, New England, and New York, while air masses of polar origin moved southward almost continuously over much of the western half of the United States. Consequently, the month of January was abnormally warm in the East and South and abnormally cold in the Pacific States, the Plateau and Rocky Mountain regions, the Plains States, and, at times, the upper Mississippi Valley.

The extremely heavy rainfall over the Ohio Valley, Tennessee, and Arkansas and part of the adjoining areas was in general caused by the fact that this area was so located with relation to the very deep areas of high pressure on either side that at the earth's surface the line of contact between the warm, moist air from the south, and the dense, cold air of polar origin that came in over the Ohio and middle Mississippi Valleys on many days from the north and northeast, lay somewhere over this area much of the time; and the less dense warm air from the south (or southwest) was forced to rise over the cold and denser air. The rapid lifting of the very moist air of tropical origin resulted in abundant precipitation.

Heavy rain occurred over the Cumberland and Tennessee River basins during the night of January 1. The amounts were slightly in excess of 4 inches at some points. This occurred on rising rivers and quickly brought both the Cumberland and Tennessee Rivers to flood. The stages on these rivers fell slightly below flood stage about the middle of the month but rose quickly when the rains again increased. The Wabash River was at high stage at the close of December and with additional rains the first part of January the river reached flood stage and remained in flood most of the month.

Thus, the lower Ohio River was receiving considerable quantities of water from its three largest tributaries at the very beginning of January and it continued to rise at a steady rate. As early as January 8 portions of the lower Ohio River were above flood stage and on the 10th the river was above flood stage from the mouth at Cairo, Ill., to Paducah, Ky., nearly up to flood stage from there to Louisville, Ky., and from one-half to two-thirds full from Louisville, Ky., to Pittsburgh, Pa. Table 1 gives the stages on the Ohio River on this date, as well as on several following dates.

TABLE 1.—Stages of the Ohio River between 7 and 8 a. m. on 3 outstanding dates during the flood of 1937, and comparative data.

[Jan. 10, above flood stage from Cairo, Ill., to Paducah, Ky. Jan. 18, above flood stage from Cairo, Ill., to Cincinnati, Ohio. Jan. 24, (Black Sunday) above previous records from Portsmouth, Ohio, to Cairo, Ill.]

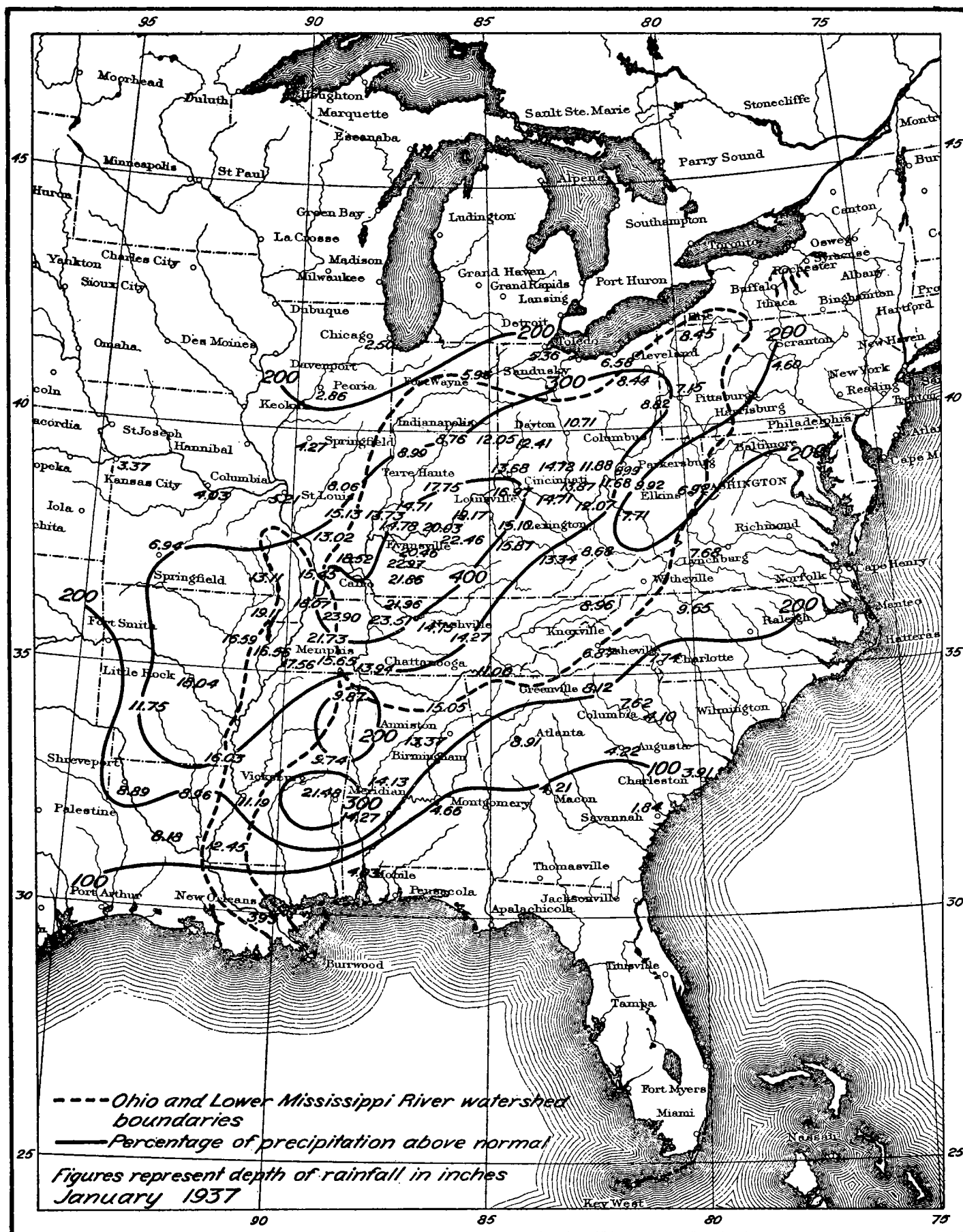
Station	Flood stage	January			Crest and date	Previous highest and year	Height of crest above	
		10	18	24			Flood stage	Previous highest
Pittsburgh, Pa.	25	19.0	22.0	29.2	34.5—Jan. 26	46.0—1936	9.5	-----
Dam No. 12, near Wheeling, W. Va.	36	19.8	28.2	45.0	48.7—Jan. 26	55.5—1936	12.7	-----
Parkersburg, W. Va.	36	18.0	35.0	50.6	55.4—Jan. 26	58.9—1913	19.4	-----
Point Pleasant, W. Va.	40	21.4	41.6	57.5	62.7—Jan. 27	62.8—1913	22.7	-----
Dam No. 28, at Huntington, W. Va.	50	23.7	46.6	63.3	69.3—Jan. 27	65.3—1913	19.3	4.0
Portsmouth, Ohio	50	28.0	50.0	68.7	74.1—Jan. 27	67.0—1913	24.1	6.2
Dam No. 33, near Maysville, Ky.	50	30.8	49.6	69.4	75.3—Jan. 27	68.4—1913	25.3	6.9
Cincinnati, Ohio	52	36.6	52.4	73.4	80.0—Jan. 26	71.1—1884	28.0	8.9
Louisville, Ky.:								
Upper gage	28	17.0	30.8	51.5	57.1—Jan. 27	46.7—1884	29.1	10.4
Low-water gage	51	36.7	53.8	75.4	81.4—Jan. 27	70.0—1884	30.4	11.4
Dam No. 45, Addison, Ky.	47	38.8	51.8	65.1	69.4—Jan. 28	60.0—1884	22.4	8.5
Evansville, Ind.	35	34.8	42.8	49.4	53.8—Jan. 31–Feb. 1	48.4—1913	18.8	5.4
Shawneetown, Ill.	33	-----	-----	-----	65.5—Feb. 2	58.0—1913	32.5	6.6
Paducah, Ky.	39	39.0	44.7	55.8	60.6—Feb. 2	54.3—1913	21.6	6.3
Cairo, Ill.	40	40.8	47.8	56.8	59.6—Feb. 3–4	56.4—1927	19.6	3.2

1 Approximated.
 2 Furnished by U. S. Engineer Office.
 3 Readings furnished by U. S. Geological Survey.

Practically all of the precipitation that occurred over the Ohio Valley during January occurred within the period from the 1st to the 24th, inclusive. During the first half of this period, 1st–12th, the rainfall was not abnormally heavy, nor was it concentrated over a small area. (See fig. 2.) However, during the second half, 13th–24th, inclusive, the rainfall was exceedingly heavy and the area of greatest intensity was located along the Ohio

River from Cincinnati, Ohio, to the mouth, extending into Arkansas. (See fig. 3.) The axis of this area followed the Ohio River from Cincinnati, Ohio, to Louisville, Ky., and from there on it lay a very short distance south of the course of the main stream.

At the beginning of the second half of the January 1–24 period the rains increased in intensity and were heavy on the 13th and 14th, and again on the 17th. By the morn-



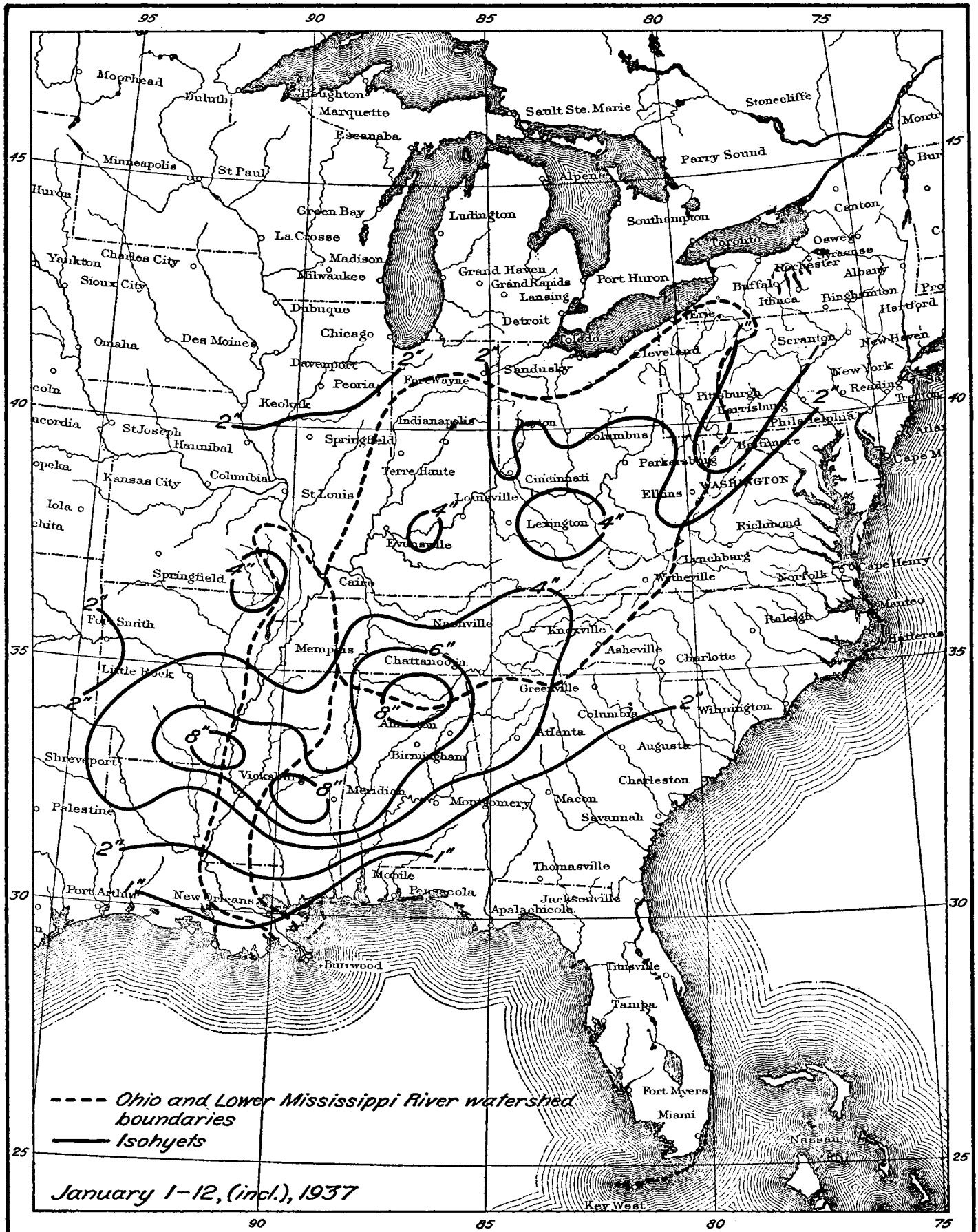


FIGURE 2.—Precipitation for January 1 to 12, inclusive, 1937.

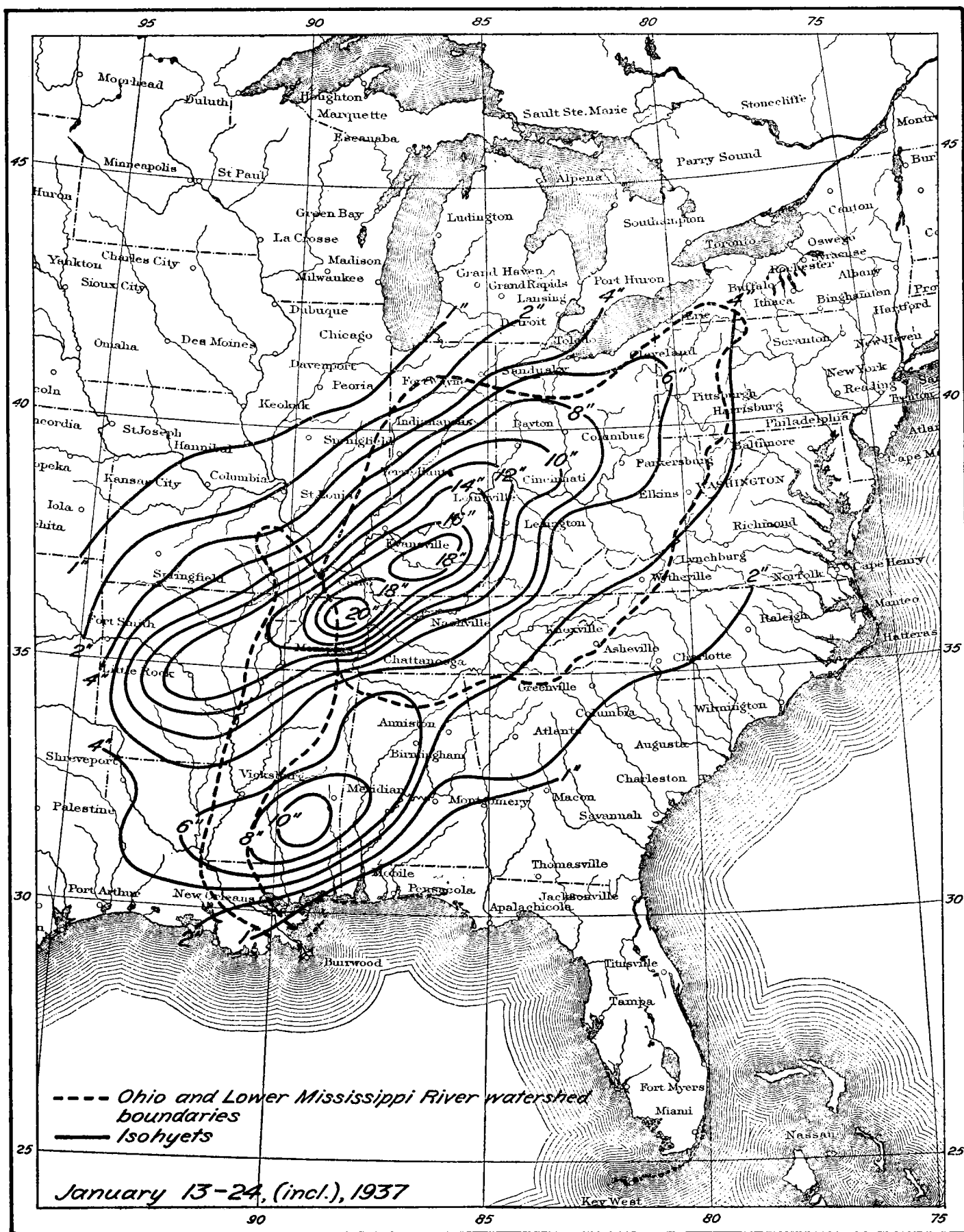


FIGURE 3.—Precipitation for January 13-24, inclusive, 1937.

ing of the 18th the Ohio River was in flood from the mouth upstream to Cincinnati, Ohio, as shown in table 1.

Beginning with the 17th, heavy and excessive rains began and continued almost without interruption until the morning of the 25th. The area of heaviest precipitation wavered back and forth across the Ohio River and it was seldom during this period that the precipitation area moved far enough from the river that the downpours did not affect it. The close proximity of the downpour to the main stream is seen in the fact that high stages did not occur in the upper sections of the Licking and Kentucky Rivers, while in the lower portions the highest stages of record occurred.

This was true, for the most part, of all the tributaries of the Ohio River, during the critical period of the flood. The Tennessee River during its second rise, did not exceed flood stage at Chattanooga, Tenn., and above; was in flood from below Chattanooga to its mouth, but did not reach record-breaking proportions. The stages in the lower portion of the Cumberland River were record-breaking, but decreased in the upper portion until they were only slightly above flood stage. The tributary streams in Pennsylvania, Ohio, and Indiana were also, for the most part, in greater flood in their lower portions. The principal tributaries in West Virginia were not in flood, with the exception of the Little Kanawha, where only minor flooding occurred.

The heavy rains falling in such close proximity to the Ohio River passed quickly into the main stream which was already full, and resulted in a rapid rise over a long reach in the river and by the morning of the 24th, which was probably the darkest moment in the history of the flood, the entire Ohio River was above flood stage and all records had been broken from Cairo, Ill., to Portsmouth, Ohio. (See table 1.) The greatest 24-hour rise from 7 a. m. to 7 a. m. on a river which was already well above flood stage occurred after exceptionally heavy rains on the 20th-21st. The water rose 6.7 feet at Cincinnati, Ohio, and 6.3 feet at Louisville, Ky., from the 21st-22d.

On the morning of the 24th occurred the final heavy downpour of the flood. The total amounts for the 12 hours between 7:30 a. m. and 7:30 p. m., eastern standard time, along the Ohio River were as follows: Pittsburgh, Pa., 0.70 inches; Parkersburg, W. Va., 0.46 inches; Cincinnati, Ohio, 2.18 inches; Louisville, Ky., 2.50 inches; Evansville, Ind., 1.34 inches; and Cairo, Ill., 0.90 inches. The stage at Cincinnati, Ohio, rose from 73.4 to 78.7 feet during the 24 hours following 7 a. m. of January 24, and at Louisville, Ky., the water rose from 51.5 to 54.8 feet during the same period. The effective rains of the flood ended shortly after this period and within a day or two the river crested at most points along the river except in the lower portion.

All previous records were broken along the Ohio River from slightly below Point Pleasant, W. Va., to the mouth at Cairo, Ill. The crest at Pittsburgh, Pa., exceeded flood stage by 9.5 feet, but was 11.5 feet below the record stage reached in March 1936. The crest at Parkersburg, W. Va., 55.4 feet, was 19.4 feet above flood stage and 7.4 feet above the March 1936 stage, but 3.5 feet below the record stage which occurred in 1913. At Cincinnati, Ohio, with a stage of 80 feet on January 26 the flood stage was exceeded by 28 feet and the previous highest stage recorded there, 71.1 feet in 1884, was exceeded by 8.9 feet. The height of the flood was greatest in the Louisville, Ky., district, where the stages were about 30 feet above flood stage and more than 11 feet above the previous highest stages of record. At Cairo, Ill., the crest reached

was 19.6 feet above flood stage and 3.2 feet above the highest stage previously recorded there. (See table 1.)

The stages in the Ohio River, particularly in the lower portion, rose at a fairly uniform rate from the beginning of the month until the crest was reached. There were several crests except in the lower portion during the first half of January, but beginning on the 13th the rains followed one another so closely that a steady and sharp rise occurred, particularly in the vicinities of Cincinnati, Ohio, and Louisville, Ky. The rises that occurred at a number of stations from 7 a. m. of January 14 until the crest was reached were as follows: Parkersburg, W. Va., 33.5 feet; Portsmouth, Ohio, 36.2 feet; Cincinnati, Ohio, 37.8 feet; Louisville, Ky., 37.6 feet; and Evansville, Ind., 15.6 feet.

On January 25 the "fuse plug levees" of the Birds Point-New Madrid floodway on the Missouri side of the Mississippi River just below Cairo, Ill., were opened allowing the water to spread out over a 130,000 acre floodway. The operation of this floodway is discussed in further detail in the Cairo, Ill., district report appearing at the end of this article. The effect of the spreading of the water over the floodway is seen in the fact that the river at Cairo, Ill., fell from 58.6 feet on the afternoon of the 25th to 57.9 feet on the morning of the 28th and then resumed a slower rise until the crest of 59.6 feet was reached on February 3-4. The rate of rise decreased materially upstream as far as Paducah, Ky.

The decrease in the rise in the lower portion of the river was also affected by a breaking through of the Ohio River to the watershed of the Cache River, which normally empties into the Ohio a few miles upstream from Cairo, Ill.

However, the Cache River overflowed the lowlands and the flow cut across southern Alexander County in Illinois and entered the Mississippi River 10 or 12 miles northwest of Cairo, Ill. This course is said by historians to have been an abandoned valley of the Ohio River. The features of this overflow are discussed in more detail in the Evansville, Ind., district report at the end of this article.

LOWER MISSISSIPPI DRAINAGE

The stages in the upper Mississippi River were quite low during the month of January and the Missouri River was unusually low as has been stated elsewhere in this report. The highest stage at St. Louis, Mo. (flood stage 30 feet) during January occurred on the 17th, when 12.8 feet was reached, then the stage dropped quickly to 7.7 feet on the 22nd and 7.0 on February 1. The river did not rise above the high point of January until February 25, when the stage at St. Louis, Mo., reached 18.8 feet.

The two largest western tributaries of the Mississippi River below Cairo, Ill., the Arkansas and the Red Rivers, drain a region which had been suffering from drought for the last three seasons and consequently did not contribute excessive water to the flood. The Poteau and the Petit Jean, tributaries of the Arkansas River, were slightly above flood stage in January. The Arkansas River proper reached flood stage only at Van Buren, Ark., on one day during January. The highest stage reached at Little Rock, Ark., was 18.8 feet on January 18, about 4 feet below flood stage, and the stage dropped to 11.2 feet on February 1. The river rose again to 17.6 feet on February 3 but fell quickly to 7.5 on the 10th. All of the tributaries of the Red River were mostly in light to moderate flood during much of January except the Ouachita River, which was in high flood with the highest stage at Camden, Ark., on January 25, reaching 41.5 feet, which is 0.5 foot

higher than in April 1927. The Red River proper, however, only exceeded flood stage by 1 foot at Alexandria, La., on February 2. The highest stage reached in the Red River at Shreveport, La., was 23.2 feet (flood stage 39 feet) on January 29. On February 10 the stage had fallen to 16.3 feet and on February 19 to 10.7 feet.

In the White Basin the Black River was only in moderate flood and in the White River flood stages were not exceeded above Calico Rock, Ark. The crest reached at Georgetown, Ark., was 30.3 feet on January 24-25, which is the same as in April 1927, but the levees held this time and not in 1927.

Of the remaining tributaries of the lower Mississippi River the St. Francis and the Yazoo Rivers had considerable flooding which began early in January in the upper portion and continued into March in the lower portions, the flooding during the latter period being due to backwater from the Mississippi River.

At the beginning of the rise in the Ohio River late in December the stages in the Mississippi River below Cairo, Ill., were very low. The stage at Memphis, Tenn., on December 31, was 9.2 feet and at New Orleans, La., 2.6 feet.

The prevailing low stages along the lower Mississippi River at the time of the beginning of the flood in the Ohio River, together with the low stages in the Mississippi River above Cairo, Ill., and the fact that the western tributaries of the lower Mississippi River did not at any time discharge more than moderately high amounts, and at the time of the crest in the Mississippi River their discharges had dropped off, all helped to prevent a super flood in the Mississippi River.

As it was, all previous records were broken from the mouth of the Ohio River to Helena, Ark., and at Natchez, Miss. Table 2 shows the height of the crest and the date, as well as the previous highest stages, along the lower Mississippi River.

TABLE 2.—Highest stages reached along the lower Mississippi River in 1937 in comparison to the previous highest stages of record

Station	Flood stage	Crest and date	Previous highest and year	Height of crest above	
				Flood stage	Previous highest
New Madrid, Mo.	34	47.9—Feb. 2-5 ...	41.6—1913	13.9	3.3
Memphis, Tenn.	34	48.7—Feb. 10.	14.7
Beale Street gage.	35	50.3—Feb. 10.	46.6—1913	15.3	3.7
Helena, Ark.	44	60.3—Feb. 11.	56.8—1927	16.3	3.5
Arkansas City, Ark.	42	53.8—Feb. 12-15 ...	60.4—1927	11.8
Greenville, Miss.	36	52.2—Feb. 15.	54.7—1927	16.2
Vicksburg, Miss.	43	53.2—Feb. 21.	58.6—1927	10.2
Natchez, Miss.	46	58.0—Feb. 21-25 ...	58.6—1927	12.0	1.4
Baton Rouge, La.	35	45.0—Feb. 23.	47.8—1927	10.0
New Orleans, La.	17	19.3—Feb. 28.	21.3—1922	2.3

Flood stage was first exceeded on the lower Mississippi River on January 13 at New Madrid, Mo., and the last station to pass flood stage was New Orleans, La., on February 7. The first date that the river fell below flood stage at any point was on February 26 at New Madrid, Mo., and the last point to fall below flood stage was at Baton Rouge, La., on March 23.

With the exception of Natchez, Miss., the crests in the river below Helena, Ark., were below the peaks reached in 1927. The high stage reached at Natchez, Miss., is undoubtedly due to the action of the 12 cut-offs in the Mississippi River between the mouths of the Arkansas and Red Rivers, which helped to lower the stages in the upper portions of the region affected by hastening the progress of

the water but in so doing piled up the water in the lower portion and at Natchez, Miss., which is 2 miles below the last cut-off.

Although the stages below Natchez, Miss., were 1.0 to 2.8 feet below the 1927 stages, the crest on the Atchafalaya River at Simmesport, La., was 4.1 feet lower than the 1927 crest. The cause of this discrepancy has been explained in the New Orleans, La., district report appearing at the end of this article.

The Bonnet Carre spillway located 23 miles upstream from New Orleans, La., was opened by the United States Engineers late in January, diverting a portion of the water from the river into Lake Ponchartrain. The resultant lowering of the stage at New Orleans, La., is estimated to be not less than 3 feet.

LOSS AND DAMAGE

It is impossible to give even an estimate of the amount of loss and damage that occurred in the Ohio and lower Mississippi Valleys at this time. The hardest hit of the larger cities probably was Louisville, Ky., where nearly 70 percent of the city was under water and about 175,000 people were forced to leave their homes. Jeffersonville, Ind., across the river was 90 percent inundated and 13,000 people fled from their homes. In the Evansville, Ind., district about 90,000 people were forced from their homes. Cincinnati, Ohio, because of its higher elevation, was probably more fortunate in that only 10 percent of its area was covered by water. However, the city was practically paralyzed by loss of water, power, heat, and light and nearly helpless to combat fires that broke out.

There were a number of smaller cities along the lower Ohio River that were completely submerged. The whole city of Paducah, Ky., with a population of between 30,000 and 40,000, was evacuated. Complete information of the extent of the inundation in the flooded area is not available at this time.

The city of Portsmouth, Ohio, was protected by a 60-foot wall which safely withstood the flood of March 1936. However, in the present flood the height of the water exceeded the top of the wall by more than 14 feet. As soon as it became apparent that the river stage would exceed the top of the wall, action was taken to permit the water to enter the city through openings in order to minimize the force of the current flowing over the wall. However, the rise in the river was so rapid that this action was only partially successful and considerable damage occurred from water rushing over the wall. Cairo, Ill., on the other hand, was safe behind its 60-foot wall as the crest of the river went up to 59.6 feet.

The extreme upper portion of the Ohio River, which was so hard hit in March 1936 escaped the worst part of this flood. At Pittsburgh, Pa., the damage was not great although the flood stage was exceeded by 9.5 feet. The losses increased in amount proceeding downstream.

The damage along the lower Mississippi River was confined almost entirely to the overflow between the banks and the levees and in the backwater areas of the tributaries. Because of the time of the year the losses of actual and prospective crops were not great. The levee system improved and constructed after the disastrous flood of 1927 withstood the exceptionally high stages remarkably well and no levee breaks occurred unless the overflow at the Bessie Landing cut-off in Tennessee can be considered as a levee break.